

Updated 12/2003

**Watershed Restoration Action Strategy (WRAS)
State Water Plan Subbasins 03H and 03I
Christina River Basin
(Brandywine Creek and White Clay Creek Watersheds)
Chester, Delaware and Lancaster Counties**

Introduction

The Christina River basin totals 402 square miles in Pennsylvania and consists of two state water plan subbasins, 03H and 03I. Subbasin 03H includes the 301 square mile Brandywine Creek watershed, which enters the Christina River close to its confluence with the Delaware River, after flowing through the Delaware City of Wilmington. Subbasin 03I, at 98 square miles is one of the smallest PA subbasins, includes White Clay Creek and its major tributary Red Clay Creek, and the headwaters of the Christina River. White Clay Creek flows into the Christina River at Christina, Delaware. The Red Clay Creek joins the White Clay Creek close to its confluence with the Christina River. A total of 372 streams flow for 536 miles in subbasin 03H and 118 streams flow for 192 miles in subbasin 03I. Both subbasins are included in **HUC Area 2040205**, Brandywine/ Christina River, a Category I, FY99/2000 Priority watershed under the Unified Watershed Assessment.

Geology/Soils

The two subbasins lie mostly within the Northern Piedmont Ecoregion, Piedmont Uplands (64c), an area of complexly folded igneous and metamorphic crystalline rocks. The northern half of the subbasin is largely gneiss, quartz monzonite, granite gneiss, and grandorite of the Precambrian age. Subbasin 03I and most of the lower half of 03H are comprised of schist of the Wissahickon and Peters Creek Formations of the Lower Paleozoic Age. A band of gneiss and gabbro extends from Dowingtown through Chadds Ford. Small areas of marble, an important building stone used extensively in the past, is found in subbasin 03H. A tiny portion of the uplands consisting of serpentine rocks, which hosts several rare plants, is referred to as the Barrens. Groundwater yields in the uplands are highly variable due to the many types of metamorphic and igneous formations. Graphitic gneiss and grandorite rocks have the lowest water yields. Soils derived from the Piedmont Uplands rocks have a moderate rate of water infiltration; slopes range from 15 to 20 percent. The predominant soil association of the uplands is a well drained, medium textured soil overlaying the gneiss and schist.

The topography of these subbasins consists of low rounded hills and ridges, irregular plains and narrow stream valleys. The highest point is the northwestern Brandywine Creek watershed divide at the Welsh Mountains near Honey Brook.

A narrow eastern-extending tongue of the Northern Piedmont Limestone/Dolomite Lowlands (64d) subecoregion, consisting of limestone strata, passes through the center of subbasin 03H, roughly following the main line Conrail railroad tracks through Dowingtown and Coatsville. A small portion of the area south of Honeybrook in the northwest corner of subbasin 03H is also in this ecoregion. Small bands of limestone are also interspersed with the schist in the northern portion of subbasin 03I. Creeks in the Piedmont Limestone Lowlands maintain more a consistent year-round flow and cooler water temperatures than streams in the uplands. They are subject to sinkholes and contamination through fractures. Limestone-derived soils have slower infiltration rates than those of the uplands unless associated with fractures. Limestone is an excellent aquifer with high yielding water supply wells. Several limestone quarries are in operation in this band.

Land Use

Subbasin 3H and 03I contains a mix of agricultural and rural use, with urban and suburban areas and scattered forests and woodlots. The most highly developed, populated area extends along the Main Line

railroad corridor and US Route 30 from Parksburg through Coatsville, Downingtown, Exton and the western edge of West Chester Borough. Development has also occurred adjacent to US Route 1, which traverses both subbasins. The PA Turnpike crosses the upper portion of subbasin 03H.

The population of subbasin 03H was 155,865 in 1990 and is expected to increase significantly to 238,641 by 2040. Subbasin 03I had a population of 32,601 in 1990 and is expected to increase to 45,523 by 2040. The townships of Chadds Ford, Uwchlan, Upper Uwchlan, West and East Whiteland, West Goshen, and East Bradford near West Chester, Downingtown, and Exton are developing rapidly. The rural nature and the easy access to the PA Turnpike, US Route 1, PA Routes 30 and 100, and commuter rail service to Philadelphia is spurring growth of these townships. Corporate and industrial parks and shopping centers are expanding in the area between the Turnpike and Route 30 and along PA Route 100 in the western portion of subbasin 03H.

In 1995, 39% of the Brandywine Creek watershed, including the portion in the State of Delaware was in agricultural land use. In Chester County, the majority of the farms were dairy operations, with cash crops and livestock the 2nd and 3rd most common agricultural use. Sixty-five percent of the farms had conservation plans. The upper East Branch and West Branch, Doe Run, Buck Run, and the lower West Branch have the highest concentration of farms in subbasin 03H.

The fertile farmland in the schist-derived soils of subbasin 03I has allowed the subbasin to become the center of mushroom growing in the United States. A knob of gabbroic gneiss between Honey Brook and Wagontown known as the Barron Hills is one of the larger forested tracks in the region. This area of poor soil is surrounded by fertile limestone soils of the Piedmont Lowlands.

Subbasin 03H has historical significance for the early settlement of Pennsylvania, the Revolutionary War and early Pennsylvania industrial growth. Coatsville and Downingtown, on the West and East Branches of the Brandywine Creek, were once important industrial centers. The first rolling steel mill in the United States was founded in the city of Coatsville in 1793; the mill later became Lukens Steel Co. The steel industry has significantly declined and these old cities and boroughs are in need of urban renewal.

Five dams were constructed in the Brandywine Creek valley as part of the Brandywine Watershed Work Plan. These dams are used as water supplies, recreation, and flood control for downstream communities.

The dams and their date of construction are:

- Marsh Creek Dam (1974) total storage available 4 billion gallons of water, used only during dry periods. A total of 13.4 million gallons a day are available to support water supply withdrawals.
- Hibernia Dam (Chambers Lake) (1994) total storage available 400 million gallons of water, used only during dry periods. A total of 4.0 million gallons a day are available to support water supply withdrawals.
- Struble Dam (1970) total storage available 528 million gallons of water used for recreation and flood control.
- Barneston Dam (1983) total storage available 511 million gallons used for flood control.
- Beaver Creek Dam (1974) total storage available 184 million gallons used for flood control.

DEP Chapter 93 Stream Classifications:

Migratory Fishes:

Many of the streams in this subbasin have protected use status for migratory fishes which includes anadromous fish such as shad and herring as well as the catadromous eels.

DEP Chapter 93 High Quality (HQ) or Exceptional Value (EV) streams:

EV:

- East Branch White Clay Creek, source to the Avondale Borough northern border
- Unnamed tributary (#00194) to UNT#00193 to West Branch Brandywine Creek at River Mile 0.3
- Unnamed tributary (#00108) to West Branch Brandywine Creek at River Mile 5.2
- Broad Run at Northbrook (tributary to West Branch Brandywine Creek)

HQ:

- Unnamed tributaries to West Branch Brandywine Creek in West Brandywine Township
- Birch Run, near Wagontown, source to Hibernia Park Dam
- Unnamed tributary (#00215) to West Branch Brandywine Creek at River Mile 21.2
- East Branch Brandywine Creek, main stem and unnamed tributaries from source to Shamona Creek
- Indian Run
- Culbertson Run
- Marsh Creek
- Shamona Creek
- Unnamed tributaries to East Branch Brandywine Creek in East Brandywine and Uwchlan Townships
- Broad Run, at Talcose (tributary to East Branch Brandywine Creek)

Parks, Preserves and Historic or Recreational Features:

- Marsh Creek State Park: 1,705 acres with a 535-acre lake
- White Clay Creek Preserve: 1,253 acres of lower main stem White Clay Creek and Broad Run
- Struble Lake 146 acres (PA Fish and Boat Commission)
- Stroud Center: a private research center and preserve located near London Grove
- Brandywine Battlefield Revolutionary War site adjacent to Brandywine Creek along US Route 1 near Chadds Ford.
- Longwood Gardens, 1050-acre private horticultural garden and woodlands located off US Route 1 near Kennett Square.
- Lower Brandywine Creek is an excellent canoeing stream

Water Supplies:

Numerous water supplies are located in the two subbasins. The majority use wells as their water sources. The Brandywine Creek provides drinking water to thousands of residents. Several reservoirs are located in 03H: Coatsville Reservoir on Rock Run and the Downingtown Copeland Run Dam. Water is also withdrawn for irrigation of farms and golf courses. Most of subbasin 03H has groundwater protection status under the Delaware River Basin Commission. Coatsville also draws water for their use from the West Branch Octoraro Creek, a transfer of water from the Susquehanna River basin. Other boroughs and townships use wells within the 03H subbasin.

In subbasin 03I, the Boroughs of West Grove, Avondale, and Kennett Square draw water from several wells for use as water supplies. Kennett Square also has a water intake on the East Branch Red Clay Creek. Other communities purchase water from the Chester Water Authority whose source is a reservoir on the Octoraro Creek in the Susquehanna River basin. Up to 25% of the potential water in the Octoraro Creek watershed is withdrawn and transferred to this and other subbasins in southeastern Pennsylvania.

Water Quality Impairment

Industrial and urban development in the cities and boroughs of West Chester, Coatsville, Downingtown and Parkesburg have resulted in degradation of portions the Brandywine Creek watershed from municipal and industrial discharges and urban runoff and storm sewers. The persistence of the pesticide Chlordane in soils of the watershed has resulted in a “no fish consumption advisory” on the main stem Brandywine

Creek from US Route 1 down to the Delaware State line. Streams through the urbanized areas also suffer from habitat alterations, flow variability, and siltation. Municipal point source discharges also cause organic enrichment and low dissolved oxygen in Beaver Creek, Buck Run, the Middle Branch White Clay Creek, and Broad Run.

The streams in subbasin 03H with the most impairment are those in the industrial/urban areas of Downingtown (East Branch Brandywine Creek and Beaver Creek), Coatsville (Valley Creek, Sucker Run, and West Branch Brandywine Creek), Parksburg (Buck Run), and West Chester (Taylor Run). These impaired areas also have some of the highest percentage of impervious surface in the subbasin. The highest percentages of impervious surface are in West Valley Creek watershed (20%), which flows into Downingtown and the lower East Branch Brandywine Creek near West Chester (15%). Streams in the Honey Brook area (upper East Branch, West Branch and Honey Brook Creek) are impaired due to agricultural runoff.

Subbasin 03I streams with the most impairment are associated with the mushroom farm region near Kennett Square, Kaolin, Avondale, and West Grove. Agricultural runoff resulting in siltation and excess nutrients from mushroom farms is a problem in portions of main stem White Clay Creek and its East and Middle Branches, Broad Run, and Red Clay Creek watersheds.

Urbanization and paving can have a severe effect on stream aquatic life. Studies by the Maryland Department of Natural Resources stated that a reduction in stream aquatic species diversity may begin with as little as 2% impervious cover. Maryland streams with above 15% impervious cover were rated fair to poor for aquatic species. When the impervious cover reached 25%, species diversity was significantly reduced. Riparian vegetation removal and paving affect both stream water temperature and habitat for aquatic species. Organisms most affected include many species of reptiles and amphibians, brook trout, and stoneflies. Stormwater runoff from paved areas can also wash out oil and grease and other pollutants into streams. The paved areas also restrict replenishment of groundwater and contribute to flash flooding during storm events and extreme fluctuations in stream water levels. Extreme flow fluctuations cause difficulties in the attachment of bottom dwelling organisms to the stream substrate and also cause a scouring of the substrate. Retention of riparian vegetation in unnamed headwater tributaries, known as first order streams, which may comprise as much as 50% of the streams in a watershed, can be especially critical to the protection of organisms in the downstream watershed.

Monitoring/Evaluation

Most of subbasins 03H and 03I were assessed under the unassessed waters program in 1997. Ninety-six percent of subbasin 03H has been assessed. A total of 96 miles or 18% of the subbasin streams are impaired; 410 miles or 82% of the assessed streams are unimpaired. Seventy-three percent of subbasin 03I has been assessed. More than 143 miles or 61% of the assessed streams are impaired, mainly from agricultural sources.

The remaining unassessed stream miles (35.51 miles) should be completed by the fall of 2002.

Stream Assessment Summaries for 03H (Brandywine Creek) and 03I (White Clay Creek) based upon data through October 2000.				
SWP Watershed	Miles of Stream Impaired	Miles of Stream Attaining	Miles of Unassessed Streams	Total Miles
3H	102.94	427.5	5.41	535.85
3I	108.44	53.26	30.1	191.8
Total	211.38	480.76	35.51	727.65

Sources of Impairment for Assessed Streams in Subbasins 03H and 03I based upon data collected through October 2000.						
Protected Water Use (Chap. 93)	Source of Impairment	Miles Impaired	Miles Impaired by SWP	% Impaired of Miles Assessed	Data Source	Priority
Aquatic Life	Agricultural	129.19	46.38(03H) 82.81(03I)	18	303d list	High
Fishing	Fish Consumption Advisory*	56.35	5.85(03H) 50.5((03I)	na**	“	High
Fishing	Industrial Point Source***	50.5	50.5(03I)	7	“	High
Aquatic Life	Urban Runoff/Storm Sewers	43.13	30.82(03H) 12.31(03I)	7	“	High
Aquatic Life and Fishing	Unknown Sources****	38.53	35.79(03H) 2.74(03I)	5	“	High
Aquatic Life	Habitat Modification	16.65	12.31(03H)	2	“	Low
Aquatic Life	Hydromodification	12.91	6.66(03H) 6.25(03I)	2	“	Low
Aquatic Life	Municipal Point Source	11.8	11.8(03I)	2	“	High
Aquatic Life	Construction	7.93	7.93(03I)	1	“	Low
Aquatic Life	Other	2.31	2.31(03H)	<1	“	Low
Aquatic Life	Natural Sources	0.68	0.68(03H)	<1	“	Low
	Total	211.38				

*= Calculated from miles for Industrial Point Sources and Unknown Sources for PCBs and Chlordane
 **=Fish Consumption Advisories are based on a limited number of samples that do not assess the whole watershed.

***=Source of PCBs for Red Clay Creek watershed Fish Consumption Advisory.

****=Source of PCBs and Chlordane for West Branch Brandywine Creek. Also includes source of impaired aquatic life uses in 3H and 3I.

+ =Total miles exclude mileage for Fish Consumption Advisory as these miles are accounted for in the Industrial Point Source and Unknown Sources.

DEP biologists use a combination of habitat and biological assessments as the primary mechanism to evaluate Pennsylvania streams under the Unassessed Waters Program. This method requires selecting stream sites that would reflect impacts from surrounding land uses that are representative of the stream segment being assessed. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment. The length of the stream segment assessed can vary between sites. Several factors are used to determine site location and how long a segment can be, including distinct changes in stream characteristics, surface geology, riparian land use, and the pollutant causing impairment. Habitat surveys and a biological assessment are conducted at each site. Biological surveys

include kick screen sampling of benthic macroinvertebrates, which are identified to family in the field, and an evaluation of their tolerances to pollution. Benthic macroinvertebrates are the organisms, mainly aquatic insects, that live on the stream bottom. Since they are short-lived (most have a one-year life cycle) and relatively immobile, they reflect the chemical and physical characteristics of a stream and chronic pollution sources or stresses. Habitat assessments evaluate how deeply the stream substrate is embedded, degree of streambank erosion, condition of riparian vegetation, and amount of sedimentation.

The Brandywine and White Clay Creek watersheds have experienced large increases in population growth since 1945. Residential, commercial, and industrial land development in the watersheds has substantially increased impervious areas (roads, parking lots, buildings, and driveways). Stormwater associated with development impacts both the quantity and quality of water entering streams. Many developed areas have impervious surfaces directly linked to streams through piping without stormwater controls. Other developed areas have stormwater controls that were created to attenuate peak discharges to predevelopment levels. These controls may help limit downstream flooding, but do little to protect aquatic life and habitat. Neither the Brandywine nor White Clay Creek watersheds have approved Act 167 Stormwater Management Plans. Typically these plans provided little benefit for aquatic life. The plans do not require stormwater management for areas that have been developed in the past and they do not protect channels from smaller bank-full storm events that shape aquatic habitat.

Many pollutants are deposited or placed on impervious areas and urban/suburban landscapes (lawns, golf courses, athletic fields). These pollutants include animal feces, oil, fertilizers, pesticides, anti-freeze solution, and solids. These pollutants discharge directly to the stream in developed areas that lack stormwater pollution controls (infiltration areas, vegetated detention basin, and retention ponds). Stormwater Management Plans can have water quality objectives for new development and some municipalities located in the watersheds will fall under the federal stormwater regulations (Phase II).

Increasing the frequency of bank-full storm events and overall storm flows causes bank destabilization, increased sediment load, increased scour, increased substrate embeddedness, increased sediment deposition, and increased nutrient loading (eutrophication). Channels can widen or deepen causing a loss or alteration of aquatic habitat. All of these stormwater impacts adversely affect aquatic life. Hydrologic modifications associated with stormwater are important causes of aquatic use impairment in the watersheds.

Municipal wastewater treatment plants serving concentrated population centers within the subbasins discharge significant amounts of treated nutrient containing effluent. The Middle Branch White Clay Creek is listed for municipal point source impairments caused by nutrients. While municipal point sources are regulated under the state administered federal NPDES program, large treatment facilities on small watersheds overwhelm the streams capacity to assimilate treated effluent. Wastewater treatment facilities in the Brandywine Basin do not currently have discharge limits for phosphorous, however, when the Christina Basin Low flow TMDL is implemented phosphorous controls may be required for some discharges.

Agriculture impairments impact the East and West Branches of Brandywine Creek, Plum Run, Radley Run, Sucker Run, Buck Run, East and West Branches of Red Clay Creek, East and Middle Branches of White Clay Creek, Broad Run, Bucktoe Creek, Egypt Run, Indian Run, Trout Run, Walnut Run, Red Clay Creek, and White Clay Creek. Crop and animal production can adversely impact aquatic life. Erosion of topsoil and runoff of applied manure or chemical fertilizers contribute to stream sedimentation and nutrient loading. Barnyard runoff of manure and proximity of livestock to the stream can also contribute to nutrient loading and sedimentation (bank destabilization) respectively. Agricultural best management practices are voluntary and little regulation exists for reducing pollutant loads from agricultural areas.

Excess nutrients can adversely impact stream aquatic life. Increasing nutrients associated with treated sewage effluents can cause excessive algal growth, alter periphyton (attached algae) community composition, and cause large dissolved oxygen swings with low dissolved oxygen during time periods when photosynthesis is not occurring. Low oxygen associated with high algal standing crop and changes in algal communities can alter macro invertebrate and fish populations.

DEP regulates point source discharges by requiring such discharges to obtain an NPDES permit. NPDES permits establish effluent limits, specify self-monitoring requirements, and require submission of periodic reports known as discharge monitoring reports (DMRs). For surface waters, the major point sources of pollution are sewage treatment plants, industrial facilities, and “wet weather” sources like combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and storm sewers. Sewage treatment plants treat and discharge wastewater from homes, public buildings, commercial establishments, some storm water sewers, and some industries. Many industrial facilities treat and discharge their own wastewater, either directly to nearby waters, or to sewage treatment plants. Combined sewers combine storm water and sewage in one system and, during periods of intense rainfall, can overflow directly to nearby waters without treatment. Several sanitary sewer systems in the watersheds experience overflows due to excessive infiltration and inflow of surface water and groundwater into the sewer lines.

Within the Brandywine and White Clay Creek watersheds, there are 100 facilities under an individual NPDES permit that can be classified as point sources. Of these, 21 are municipality, 40 are non-municipal sewage plants (e.g. homes, schools, mobile home parks), and 39 are industrial facilities. Additional approvals for coverage under a general NPDES permit have been granted for stormwater discharges associated with industrial activities (e.g. industrial site runoff, construction site runoff, petroleum groundwater cleanup discharges, etc.).

Major sources of pollution to groundwater are septic systems, cesspools or dry wells used to dispose of industrial and commercial wastewater. Additional sources of groundwater and surface water contamination include: leaking storage tanks and leaking pipes and poor handling, storage and disposal of waste and chemicals at industrial and commercial facilities and landfills. Petroleum compounds and solvents account for most of the contamination, while elevated levels of metals, non-organics, pesticides and PCBs may also be present in groundwater.

U.S. Geological Survey (USGS) Data Summary:

The USGS has had a cooperative water resources investigation program with Chester County since 1969 to measure and describe the water resources of the county. The Chester County Water Resources Authority (CCWRA) was established in 1961 primarily for land acquisition and planning for flood control and water supply projects. CCWRA is the major cooperator in the USGS studies of Chester County streams and groundwater. The rapid growth that has occurred in the county since the 1980's has caused the CCWRA to broaden its focus from flood control to water supply planning, water quality, and groundwater and surface water management. A system of stream flow gauges provides real time information that can be used as a flood warning alert. Eleven of the gauges also provide water quality data. Water quality is monitored on the West Branch Brandywine Creek at Modena, on the East Branch below Downingtown, and on the main stem at Chadds Ford. Temperature, pH, specific conductance, and dissolved oxygen (DO) are measured hourly and fecal bacteria are monitored weekly. Groundwater quality has also been measured since 1925. Since 1970, stream benthic invertebrates have been monitored annually at 51 locations in the county. Studies to evaluate the effects of urbanization are underway in Red Clay Creek and West Valley Creek watersheds.

The USGS continuous monitoring has shown a more recent improvement in minimum dissolved oxygen (DO) in the East Branch Red Clay Creek compared to measurements from before 1989, with fewer

readings below 5 mg/l, the minimum concentration needed to support a healthy aquatic environment. Studies have shown, however, that nitrate concentrations are increasing with time in the base flow of the West Branch Red Clay Creek. Stream flow studies have also shown that the West Valley Creek basin, located primarily in the limestone lowlands, has several losing stream segments that have the potential to move contaminants into the groundwater table.

Phase III Report (1999) for Water Quality Management Strategy:

- Bacteria levels have decreased 10-fold along the Brandywine Creek at Chadds Ford, from 1982 to 1995 due to improved wastewater treatment technology, agricultural conservation programs, and better septic systems.
- Biological diversity has increased at 16 stream monitoring stations, believed to be due to new precautions on pesticide use.
- Sediment loads have increased slightly; improvement is expected, however, after completion of the Chester County Conservation District (CD) agricultural soil conservation projects.
- Dissolved oxygen levels have increased since 1990 along the Brandywine Creek due to more stringent wastewater treatment standards imposed by DEP.
- Levels of phosphates have remained the same but levels of nitrogen have increased. The TMDL under development will identify reductions in nutrients from point source wastewater discharges needed to meet standards.
- Zinc levels remain the same; superfund programs are working on clean up of zinc pollution sources along Red Clay Creek at Kennett Square.
- Biological habitat conditions have worsened over the past few decades due to increased stormwater runoff and associated runoff from development. Habitat restoration is underway through Chester County CD's Buck Run Riparian Corridor Planting.
- Impervious cover has increased due to suburban growth from 9% in 1975 to 16% for the entire Christina basin, including the State of Delaware. Recent scientific studies indicate that stream habitat, wetlands, water quality and trout streams become impaired when impervious cover reaches a threshold of 10 to 15%.
- Open Space: Pennsylvania and Chester County has sought to protect open space through purchases and additions to state and county parks, such as Marsh Creek, Chambers Lake, and Struble Lake. Private preservation groups such as the Brandywine Conservancy, Brandywine Valley Association, Red Clay Valley Association, and White Clay Watershed Association actively manage open conservation lands.

Future threats to water quality

The 1999 Phase III Christina Basin Report stated that subbasins 03H and 03I were subject to the following percentages of potential point and nonpoint source pollutants:

- Agriculture: 40%
- Permitted (NPDES) wastewater treatment facilities: 82 outfalls
- Roadways: 2%
- Urban/suburban runoff: 27%

As suburban development spreads through the region, stormwater management will be a critical need to prevent flooding and stream habitat destruction. None of the watersheds in the two subbasins have Pennsylvania Act 167 stormwater management plans.

Restoration Initiatives

Pennsylvania Growing Greener Grants:

- \$30,000 (FY 2003) to West Marlborough Township to create a watershed restoration partnership in the Buck Run Watershed.

- \$2,000 (FY2002) to the Chester County Conservation District for an East Caln Township project to improve retention time in upstream storm water basins, as well as restore a section of eroded stream channel downstream from the basins where there is severe bank erosion.
- \$35,612 (FY2001) to Chester County Conservation District for restoration of Traders Run.
- \$70,000 (FY2001) to West Marlborough Township for restoration and installation of agricultural best management practices in Buck Run.
- \$85,500 (FY2000) to Chester County Conservation District for mushroom farm environmental management, planning and implementation.
- \$83,810 (FY2000) to the Brandywine Valley Association for the watershed watch training program.
- \$150,000 (FY1999) to Chester County Conservation District for continuation of the Brandywine, Red Clay, White Clay Creek restoration project. Agricultural BMPs will be used to reduce nonpoint source pollution.
- \$131,250 (FY1999) to Downingtown Main Street, Inc. for the Park Run restoration project to continue the ongoing cleanup and conversion of a brownfields site in the Borough of Downingtown. Eroding streambanks will be planted with native vegetation.
- \$13,000 (FY1999) to Chester County Conservation District to develop a self-guided tour through the Christina River basin and Valley Creek watershed to showcase stormwater management practices.
- \$12,905 (FY1999) to the Brandywine Conservancy to restore the original hydrology to a 6.5-acre disturbed wetland in their reserve. Ditches will be backfilled and diked and a selection of native plants will be reintroduced.
- \$239,811 (FY1999) to Downingtown Borough to construct an enhanced detention basin on Park Run. Other components of the project include a stormwater feasibility study and public outreach and education.
- \$15,468 (FY1999) to the Natural Lands Trust for streambank and wildlife habitat restoration in the Buck Run watershed. Components of the project will include streambank fencing and crossings, tree and shrub plantings for riparian buffers, and alternative watering sources for livestock.

U.S. Environmental Protection Agency (EPA) Clean Water Act Section 319 Grants:

- \$291,103 (FY2003) to the Chester County Conservation District for phase 2 of the Brandywine-Christina River restoration program.
- \$29,000 (FY 2003) and \$209,880 (FY2002) to Avondale Borough for restoration of White Clay Creek streambanks.
- \$121,830 (FY2002) to Borough of Downingtown for installation of riparian buffers on Parke Run.
- \$15,918 (FY2002) to Chester County Conservation District for phase 2 of the stream restoration at Pennington Meadows.
- \$275,000 (FY2002) to Chester County Conservation District for phase 2 restoration projects of the Brandywine/Christina River Restoration Program.
- \$58,400 (FY2001) to Chester County Conservation District for an assessment and development of a protection/restoration plan for Marsh Creek Lake watershed.
- \$173,500 (FY2001) to Chester County Conservation District to compile and review existing information for East Branch White Clay Creek and verify and quantify known problems. A stream restoration project will be implemented on Trout Run.
- \$170,000 (FY2000) to Chester County Water Resources Authority for an assessment and management plan for Chester County streams, which includes subbasins 03H and 03I.
- \$75,000 (FY1999) to Chester County CD for Mushroom Farm Environmental Planning and Implementation Project in Red and White Clay Creeks. Purpose was to implement the manual developed by DEP in 1997: Best Practice for Environmental Protection in the Mushroom Farm Community by developing 40 mushroom farm environmental management plans.
- \$60,000 (FY1998) to DRBC for the one year Christina basin stormwater monitoring program. A model will be developed to generate a TMDL to achieve water quality standards.

- \$50,000 (FY1998) to Chester County Conservation District and Water Resources Agency of New Castle County (WRANC) to develop a comprehensive strategy to address water quality problems in the Christina basin. The goal is to develop TMDL's for point and nonpoint source discharges in the basin.
- \$82,000 (FY1996) to Chester County CD for the Christina Basin Water Quality Management Program. This project funded the second year of a five-year multi-agency study to develop a strategy to address water quality issues.
- \$75,001 (FY1992) to Chester County CD for Red and White Clay Creek Watershed Program. The goals of this project were to demonstrate BMP's on mushroom and non-mushroom farms and provide for educational and technology transfer of the knowledge gained from the project.
- \$641,585 (FY96-01) 319 National Monitoring Program grant to Stroud Center for research on forested buffers. The goals of this 5-year project are to monitor, evaluate and document the benefits of experimental riparian reforestation in an agricultural watershed.

Department of Conservation and Natural Resources (DCNR) Rivers Conservation Grants:

- \$123,000 (1997) and \$100,000 (1998) to Chester County to develop a rivers conservation plan for Chester County streams, includes subbasins 03H and 03I.
- \$25,000 (1998) to Brandywine Conservancy to develop a rivers conservation plan for the East Branch Brandywine Creek.
- \$10,000 (1995) to White Clay Watershed Association to develop a rivers conservation plan for White Clay Creek.

Cold Water Heritage Program:

- \$5,000 (1999) to London Grove Township for an assessment of East Branch White Clay Creek.

Other:

- Buck Run Stream Stabilization Project repaired stream banks at the Sadsbury Township Park. This project is planning for stabilization and plantings of native grasses in this trout stocked portion of Buck Run at the main line railroad tracks. A combination of soft and hard remediation will be used. Some of the tree seedlings used were from the DEP Stream Releaf Program.
- Buck Run Farm Protected Stream Crossing Project on the William Elkins farm, part of the original King Ranch, which is under easement to the Brandywine Conservancy. Other conservation practices used have been rotational grazing and warm season grasses.
- Henry J. Stoltzfus Demonstration Project near Honey Brook, which received a Christina Basin Demonstration Project Grant to improve barnyard runoff treatment by installing a 30-foot long pipe to direct barnyard runoff to the pasture and control excess erosion.

Citizen/Conservation Groups

- Brandywine Conservancy
- Brandywine Valley Association, Inc., an 800-member group founded in 1945, is dedicated to restoring and protecting the water quality and resources of the Brandywine Creek. More information on their group can be found at the website at <http://www.bva-rcva.org/>.
- White Clay Watershed Association is dedicated to the protection and improvement of waters quality of the White Clay Creek valley. More information on their group can be found at the website at <http://www.ccil.org/~wcwa>.
- Red Clay Valley Association, founded in 1952, is dedicated to promotion of the restoration and conservation of the natural resources of the Red Clay Creek watershed. More information on their group can be found at the website at <http://www.bva-rcva.org/>.
- Christina Basin Water Quality Management Committee
- Friends of White Clay Reserve

Public Outreach

Watershed Notebooks

DEP's website has a watershed notebook for each of its 104 State Water Plan watersheds. Each notebook provides a brief description of the watershed with supporting data and information on agency and citizen group activities. Each notebook is organized to allow networking by watershed groups and others by providing access to send and post information about projects and activities underway in the watershed. The notebooks also link to the Department's Watershed Idea Exchange, an open forum to discuss watershed issues. The website is www.dep.state.pa.us. Choose Subjects/Water Management/Watershed Conservation/Watershed and Nonpoint Source Management/Watershed Notebooks.

Funding Needs

The total dollars needed for addressing all nonpoint source problems in the watershed is undetermined. Stream assessments have been conducted and TMDLs will be developed for impaired waters in the subbasin. Watershed restoration plans developed for impaired waters will help determine what Best Management Practices (BMPs) are necessary to reduce pollution sources and provide estimates of restoration needs.

Funding sources available to support the development of site-specific implementation plans and remediation projects that address the sources of water quality impairment include the EPA Clean Water Act Section 319 grant program and the newer Pennsylvania funded Growing Greener program which target reductions in nonpoint source pollution. Pennsylvania has generally placed more emphasis on funding projects slated for implementation on water bodies where TMDLs have been completed or where water quality impairments have been documented.

Total Maximum Daily Loads (TMDL's)

TMDL's identify the amount of a pollutant that a stream or lake can assimilate without violating its water quality standards. TMDL's are calculated to include a margin of safety to protect against a mathematical or data error. TMDL's are set for each pollutant causing impairment.

Draft TMDL for White Clay Creek:

A TMDL was developed for the East Branch Red Clay Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water Act Section 303d Lists. The protected uses of the East Branch Creek watershed are water supply, recreation and aquatic life. As listed in 25 PA Code Chapter 93, the designated aquatic life uses for the main stem East Branch Red Clay Creek and an Unnamed Tributary are trout stocked fishes.

The primary land use (51%) in the East Branch Red Clay Creek watershed is agriculture, with areas adjacent to the stream used for row crops, pasture, and stock-piling of spent mushroom soil. Cattle are not common in the watershed, but where they are pastured they generally have free access to the stream. The majority of the stream during the 1988 and 1997 surveys had severe bank erosion and generally lacked a riparian zone. Mushroom production is the primary agricultural activity in the watershed. Large quantities of manure are imported to the watershed to produce soil for the propagation of mushrooms. This imported manure is stockpiled adjacent to mushroom houses prior to and after preparation for use in mushroom production. Spent mushroom soil is stockpiled and composted or spread on fields, used as fill (typically in riparian areas), and sold for potting soil.

In addition to the agricultural sources, four point sources deliver nutrients to East Branch Red Clay Creek: East Marlborough Township sewage treatment plant (STP) (PA 0055107); Trans Materials SWRO (PA 0054755); Mushroom Canning Cooperative non-contact cooling water (PA 0052612); and Schindler SRSTP (PA 0050679).

The first determination that East Branch Red Clay Creek was not meeting its designated water quality uses for protection of aquatic life was based on a 1988 aquatic biological survey, which included an analysis of benthic macroinvertebrates and habitat surveys. Results indicated that East Branch Red Clay Creek was degraded due to extensive agricultural activities in the watershed, primarily from mushroom production. Department biologists concluded that water quality would remain poor until best management practices for mushroom production and mushroom soil storage were established to reduce runoff to the streams.

In 1997, the Department determined that East Branch Red Clay Creek was still impaired. The survey showed that sedimentation was a problem in addition to organic enrichment. Sediment deposited in large quantities on the streambed degrades the habitat of bottom-dwelling (benthic) macroinvertebrates. Nutrients from agricultural activities were also documented as causing increased algal growths. As a consequence of these surveys, Pennsylvania listed 2 miles of the East Branch Red Clay Creek on the 1996 Section 303d Lists of Impaired Waters. Following the 1997 survey, Pennsylvania listed an additional 10.43 miles and one new segment to the 1998 Section 303d List. The 1998 list resulted in an increase of impaired miles to 12.43 and added one new segment on an unnamed tributary to the 1996 listing. The stream segments were listed because of impacts by sediments, nutrients, organic enrichment, and low dissolved oxygen (D.O.) from agriculture.

The biological assessment used the EPA waterbody cause code for Organic Enrichment/Low Dissolved Oxygen (D.O.), to describe the impairment seen in this portion of East Branch Red Clay Creek. The listing was based on visual observation. No dissolved oxygen readings were used as the basis for this impairment listing. The listing for impairment caused by organic enrichment/ low dissolved oxygen is addressed through reduction to the phosphorus load.

Neither Pennsylvania nor EPA currently has water quality criteria for sediment or nutrients; therefore, Pennsylvania is using a method to develop TMDL's based on comparing the impacted watershed to a reference watershed to determine the appropriate watershed loading for nutrients and sediments. The Reference Watershed Approach pairs two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds should have similar land cover and land use characteristics. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the model. The objective of the process is to reduce the loading rate of nutrients and sediment in the impaired stream segments to a level equivalent to or slightly lower than the loading rate in the non-impaired, reference stream segments. This load reduction will allow the biological community to return to the impaired stream segments.

Two factors are used to select a suitable reference watershed. The first factor is to use a watershed that had been assessed by the Department using the Unassessed Waters Protocol and has been determined to attain water quality standards. The second is to find a watershed that closely resembles the East Branch Red Clay Creek watershed in physical properties such as land cover/land use, physiographic province or ecoregion, size, and geology. The Pocopson Creek, a tributary of the Brandywine Creek, was chosen as the reference watershed. The geology of the East Branch Red Clay and Pocopson Creek watersheds are very similar. The bedrock geology influences soil type as well as fractures and permeability.

The TMDL proposes reducing the phosphorus and sediment loadings in East Branch Red Clay Creek watershed to levels consistent with Pocopson Creek. Because of the similarities in land use, soils and geology between the two watersheds, achieving phosphorus and sediment loadings in the East Branch Red Clay Creek TMDL will ensure that the aquatic life use is achieved and maintained as evidenced in Pocopson Creek.

East Branch Red Clay Creek was listed as being impaired due to problems associated with dissolved oxygen levels, nutrient loads, and organic enrichment. In stream systems, elevated nutrient loads (nitrogen and phosphorus) can lead to increased productivity of plants and other organisms. Plants (at night) and organisms in the stream utilize oxygen in the water column. Excessive nutrient input can lead to elevated levels of productivity, which can subsequently lead to depressed dissolved oxygen levels when an abundance of aquatic life is drawing on a limited oxygen supply. Additional problems arise when these organisms die because the microbes that decompose this organic matter also consume large amounts of oxygen. A second effect of nitrogen (specifically ammonia) occurs when bacteria convert ammonia-nitrogen to nitrate-nitrogen. This process, called nitrification, also results in lower dissolved oxygen levels in streams.

Typically in aquatic ecosystems the quantities of trace elements are plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the limiting nutrient because its relative quantity affects the rate of production (growth) of aquatic biomass. If the nutrient load to a water body can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well. In most efforts to control eutrophication processes in water bodies, emphasis is placed on the limiting nutrient; however it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources such as nitrates in groundwater.

In most fresh water bodies, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which limiting nutrient is difficult. For this reason, the ratio of the amount of nitrogen (N) to the amount of phosphorus (P) is often used to make this determination. If the N/P ratio is less than 10, nitrogen is limiting; if the N/P ratio is greater than 10, phosphorus is the limiting nutrient. In the case of East Branch Red Clay Creek, the N/P ratio is approximately 10.2:1, which points to phosphorus as the limiting nutrient. Controlling the phosphorus loading to East Branch Red Clay Creek will limit plant growth and result in raising the dissolved oxygen level.

The following TMDL calculations include a load allocation (LA) for the nonpoint sources and a waste load allocation (WLA) for point source (permitted) discharges.

TMDL for East Branch Red Clay Creek				
Pollutant	TMDL (lb./yr.)	LA (lb./yr.)	WLA (lb./yr.)	MOS (lb./yr.)
Phosphorus	3,072	2,462	303	307
Sediment	326,552	285,108	8,789	32,655

Total Load Allocation by Land Use/ Source									
		Phosphorus				Sediment			
Source		Unit Area Loading Rate	Annual average load	LA (annual average)	% Reduction	Unit Area Loading Rate	Annual average load	LA (annual average)	% Reduction
Land Use Category	acres	lbs./acre/year	lbs./year	lbs./year		lbs./acre/year	Lbs./year	lbs./year	
Hay/Past	1759	1.37	2,408	526	78%	47.27	83,135	50,518	39%
Row Crops	346	2.59	897	288	68%	259.23	89,643	54,473	39%
Prob Row	1095	2.66	2,917	526	82%	295.83	323,702	176,237	46%

Crops									
Coniferous	371	0.01	2	2		1.62	602	602	
Mixed For	358	0.01	2	2		1.50	537	537	
Deciduous	1460	0.01	11	11		1.87	2,737	2,737	
Low Intens Dev	699	0.10	71	71					
High Intens Dev	178	1.20	214	214					
Transition*	2	0.00	0	0					
Groundwater			688	688					
Point Source			926	303	68%		14,470	8,793	39%
Septic Systems			135	135					
Total	6,269	1.32	8,271	2,765	67%	67.90	514,826	293,897	43%

*Transition= Land under development

The pollutant reductions in the TMDL are allocated to nonpoint source agricultural activities and one point source in the watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDL. Restoration efforts should focus on gaining cooperation from mushroom producers to install BMPs and proper disposal of spent mushroom compost. Additional remediation activities are streambank stabilization and fencing, restoration of riparian buffers, filter strips, collection and control of runoff from mushroom soil piles and areas around mushroom houses, and mushroom soil/manure holding structures. Reestablishing riparian zones will trap sediment and phosphorus and keep these pollutants from reaching the stream. Stabilizing streambanks will reduce instream erosion. Runoff control will allow for filtering of phosphorus and sediment through buffer strips and riparian buffers preventing these pollutants from reaching the stream. Soil holding structures will prevent phosphorus and sediment from reaching the stream by containing runoff.

The Chester County Water Resources Authority is nearing completion of a watershed management plan for county streams. When completed the plan will provide specific information on what remedies are necessary to improve stream water quality the East Branch White Clay Creek watershed.

Additional information and loadings calculated for individual land use categories can be found in the Draft TMDL on the Department's website at <http://www.dep.state.pa.us/>, directLINK, TMDL's, East Branch White Clay Creek.

Restoration/Protection Needs

Restoration efforts should be concentrated in impaired stream segments listed in the Table at the end of this WRAS. Controls for impairment from urban runoff/storm sewers should include stormwater runoff controls, reduction in stream flow variability, and restoration of flow, stream channels and riparian buffers. Agricultural impairment should be addressed with best management practices (BMPs) to control sediment and nutrient runoff, streambank fencing and restoration, and reestablishment of riparian buffers.

The Phase III Christina Basin Report has made the following recommendations for protection and restoration of water quality:

- Planting forests and buffer to filter and cleanse stormwater
- Acquiring and conserving open space
- Limiting impervious cover from new development and encouraging infiltration of runoff through watershed-based local ordinances and zoning codes.

- Increasing the financial incentives for landowners to participate in existing federally funded agricultural conservation programs
- Accelerating superfund and hazardous waste clean-up programs
- Minimizing wastewater and combined sewer overflow point source discharges.

The Chester County Water Resources Authority is nearing completion of their watershed management plan for county streams. The draft water quality restoration plan for Red Clay Creek lists the following objectives:

1. Restore water quality. Many of the streams in this watershed have fair to poor water quality. Recommended actions include:
 - Implement final Christina Basin Low Flow TMDL.
 - Accelerate implementation of agricultural BMP's such as stream corridor protection through fencing, livestock crossings, vegetative filter strips and tree plantings; completion of mushroom farm and nutrient management plans; encourage farming training and certification; and capture and control of manure runoff.
 - Implement urban BMPs in Kennett Square Borough, including street sweeping, period storm drain clean-outs, solid waste management, and storm sewer inlet labeling.
2. Reduce stormwater runoff. Priority actions include:
 - Implementation of comprehensive stormwater management criteria for new construction.
 - Review/revise municipal ordinances.
 - Provide incentives for subdivisions incorporating conservation design practices.
 - Limited pavement in turnarounds and cul-de-sacs. Changes in municipal requirements for emergency vehicles to allow more vegetated areas.
 - Smaller front yard setbacks to reduce impervious cover.
 - Runoff management systems during new construction.
 - Agricultural BMPs including conservation covers and grassed waterways
3. Expand forested riparian buffer networks particularly along first order streams, especially in the East Branch, West Branch and Burrows Run watersheds. Priority actions include:
 - Education of riparian landowners and homeowners.
 - Forest riparian buffer and conservation site design incentives.
 - Agricultural BMPs such as streambank fencing
4. Groundwater quality protection especially in the East Branch watershed. Priority actions include:
 - Utility management such as development of wellhead protection plans.
 - Municipal government programs for enhancement of groundwater recharge and septic system clean-outs.
 - Agricultural BMPs such as dividing stormwater runoff into contaminated and uncontaminated portions, proper storage of potential contaminants, and monitoring of underground storage tanks.

The Chester County Water Resources Authority has developed an initiative to protect first order streams, the upstream-most perennial tributaries, in the county. First order streams are very small and have low flow volume and are, therefore, more vulnerable to pollution sources affecting water quality and quantity. The county is promoting establishment of forested riparian buffers and streambank fencing where livestock graze. Forested buffers help maintain water temperature by shading the creek and help reduce streambank erosion and nutrient runoff. Buffers also provide paths for wildlife to reach food and cover. The Brandywine Creek has 57.8% of its watershed flowing in first order streams. White Clay Creek has 45.1% of its watershed in first order streams. More information is available on the Water Resources Authority activities at <http://www.chesco.org/water>.

Representatives from DEP attended the Downingtown Regional Stormwater Forum on Dec. 4, 2003 in Chester County. The purpose of this meeting was to gather municipal, county, state and federal personnel

to discuss flooding and stormwater management on the East Branch of Brandywine Creek. One of the common concerns raised regarded several recent storm events in 2003 where parts of Downingtown experienced severe flooding and property damage. The audience talked about existing detention basins that were not designed properly and asked what if anything could be done to ensure that retrofits to allow the small, more frequent, storm events to be more adequately managed. Most of these BMPs only were addressing the large 50 or 100-year storm events. Presentation boards were provided indicating all the locations of severe flooding within the borough. Stakeholders anticipate continuing and expanding in the future as either the Downingtown Regional Flood Mitigation Coordination Group, but more likely as the Downingtown Regional Planning Group.

References/Sources of information

- State Water Plan, Subbasin 3, Lower Delaware River. Department of Environmental Protection, July 1983
- USGS Topographic Maps
- 319 project proposals and summaries
- DEP: Watershed Notebooks, Unified Assessment Document, and information from files and databases.
- Map of Draft Level III and IV Ecoregions of Pennsylvania and the Blue Ridge Mountains, Ridge and Valley, and Central Appalachians of EPA Regions III
- State of the Watershed Report for Brandywine Creek, 1997 and 1999, Brandywine Valley Association.
- US Geological Survey Cooperative water Resources Programs in Chester County, Pennsylvania. USGS Fact Sheet 067-98, June 1998.
- Draft Plan Chester County Management Plan. Chester County Water Resources Authority. 2000.
- Draft TMDL for East Branch White Clay Creek watershed. DEP Bureau of Watershed Conservation. 2000.
- From the Mountains to the Sea: The State of Maryland's Freshwater Streams. Maryland Department of Natural Resources and U. S. Environmental Protection Agency. EPA Publication EPA/903/R-99/023. 1999.
- Information from the Chester County Water Resources Authority.
- Draft Baseline Assessment of The Brandywine Creek and White Clay Creek Watersheds. 2001. Environmental Futures Team. DEP Southeast Regional Office.

Streams in Subbasin 03H: 303d/305b Listings

Stream	Stream code	Drainage area square miles	Miles Attained	Miles Impaired	Causes/Sources/Comments
3-Brandywine Creek	00004	304	24.88 main stem & 22 UNTs	1.28, one UNT	Nutrients from “other” sources
4-East Branch Brandywine Creek	00229	124	61.56 main stem & 43 UNTs	3.42 main stem; 5.56, 5 UNTs	Flow alterations & siltation from Hydromodification, AG & Urban runoff/storm sewers <i>Upper basin- main stem & UNTs HQ-TSF</i>
5-Indian Run at Springton & one UNT	00360	6.31	6.15		<i>HQ-CWF</i>
6-North Branch Indian Run	00361	1.60	2.36		<i>HQ-CWF</i>
5-Culberson Run	00354	4.40	6.15 main stem & 3 UNTs	1.03 main stem	Nutrients & suspended solids from “Other sources” <i>HQ-TSF</i>
5-Marsh Creek & 21 UNTs	00328	20.4	26.14		<i>HQ-TSF</i>
6-Lyons Run	00345	1.68	2.1		<i>HQ-TSF</i>
6-Black Horse Creek & 4 UNTs	00336	3.84	7.66		<i>HQ-TSF</i>
5-Shamona Creek & 2 UNTs	00324	4.03	6.47		<i>HQ-TSF</i>
5-Beaver Creek at Downingtown	00297	18.0	9.29 main stem; 13.49, 13 UNTs	0.68, one UNT	Natural sources-water/flow variability
6-Valley Run	00305	4.85	4.66, 7 UNTs	3.42 main stem	Flow alterations from Urban runoff/storm sewers
5-(West) Valley Creek	00254	20.7	3.8 main stem & 3 UNTs	7.23 main stem; 18.18, 14 UNTs	Source & cause unknown <i>(RR main line and PA Route 30 are adjacent to creek)</i>
6-Broad Run at Talcose & 8 UNTs	00255	4.05	7.93		<i>HQ-CWF</i>
5-Taylor Run	00236	5.61		4.68 main stem; 6.45, 9 UNTs	Habitat modification/alterations; Urban runoff/storm sewers-siltation

5-Blackhorse Run & one UNT	00231	1.42	2.11		
4- West Branch Brandywine Creek	00085	135	77.51 main stem & 48 UNTs	4.46 main stem; 11.59, 5 UNTs	Siltation& nutrients from AG <i>Some UNTs- HQ-CWF or HQ-TSF; two UNTs- EV</i>
5-Two Log Run	00223	2.95	2.6		
5-Birch Run near Wagontown & 3 UNTs	00216	4.71	6.26		<i>Upper basin HQ-CWF</i>
5-Rock Run & 3 UNTs	00206	8.10	10.31		
5-Sucker Run	00202	4.81		3.63 main stem; 3.16 3 UNTs	Urban runoff/storm sewers- water flow variability; AG-nutrients
5-Dennis Run	00198	2.03			
5- Buck Run	00131	48.6	28.19 main stem & 15 UNTs	3.5, 3 UNTs	Siltation from AG; Habitat modification/alterations
6-Birch Run at Buck Run & 9 UNTs	00171	5.30	10.18		
6-Doe Run & 29 UNTs	00133	8.10	38.93		
5-Broad Run at Northbrook & 14 UNTs	00089	7.05	15.88		<i>EV</i>
4-Plum Run	00076	3.70		3.42 main stem, 3.67, 4 UNTs	Siltation from AG; Unknown causes from Urban runoff/storm sewers
4-Radley Run	00071	4.16	5.61 main stem & 3 UNTs	2.22 main stem	Siltation from AG
4-Pocopson Creek	00053	9.18	17.95 main stem & 16 UNTs	1.15 main stem	Siltation from AG
4-Bennetts Run & 4 UNTs	00047	2.89	6.35		
4-Brinton Run	00040	1.53			
4-Ring Run & one UNT	00038	2.16	3.92		
4-Harvey Run & 8 UNTs	00028	3.88	8.77		
4-Wilson Run	00027	3.88	1.11		
4-Beaver Creek at Granogue, DE,	00005	4.17	6.61		

& 4 UNTs					
----------	--	--	--	--	--

Marsh Creek Lake is on the 303d list as impaired due to nutrient enrichment.

Streams in Subbasin 03I: 303d/305b Listings

Stream	Stream code	Drainage area sq. miles	Miles Attained	Miles Impaired	Causes/Sources/ Comments
2-Christina River	00003	402	1.83 main stem		
3-East Branch Christina River	00481	0.92	1.34 main stem		
3-White Clay Creek	00373	61.8	3.82, 4 UNTs	1.41 main stem	Siltation, nutrients from AG
4-Middle Branch White Clay Creek	00462	25.6	4.28 main stem & 2 UNTs	11.53 main stem, 5.81, 5 UNTs	Siltation, nutrients from AG, Municipal point source
5-Indian Run at Chesterville	00475	0.75		1.09	Nutrients & suspended solids from AG
5-West Branch White Clay Creek & 9 UNTs	00465	9.92	17.18		
4-East Branch White Clay Creek	00432	33.5	14.75 main stem & 10 UNTs	8.95 main stem; 20.62, 14 UNTs	Organic enrichment/low DO, siltation, nutrients from AG, Urban runoff/storm sewers <i>EV north of Avondale Borough</i>
5-Trout Run	63874	1.41		1.7 main stem; 1.04, 2 UNTs	Siltation, nutrients from AG; Pesticides from unknown source
5-Egypt Run	00440	2.11		1.52 main stem; 2.14, 2 UNTs	Organic enrichment/low DO, siltation, nutrients from AG
5-Broad Run at Landenberg	00434	3.96	0.24 main stem	3.25 main stem; 0.85, one UNT	Nutrients, siltation, organic enrichment/low DO from AG & Hydromodification; Water/flow variability from Urban Runoff/storm sewers; Municipal point source Siltation from Construction
6-Walnut Run	00435	0.50		1.39	Nutrients from AG; Siltation from Construction; Organic enrichment/low DO from Hydromodification; Unknown cause from Municipal point source; Water flow variability from Urban runoff/storm sewers
4-Mill Creek	00422	0.47	0.54		

3-Red Clay Creek	00374	33.4	9.18, 7 UNTs	0.76 main stem	Organic enrichment/low DO, siltation from AG; Urban runoff/ storm sewers; Hydromodification, flow alterations
4-East Branch Red Clay Creek	00413	10.1	0.03 one UNT	5.28 main stem; 6.36, 4 UNTs	Organic enrichment/low DO, siltation from AG
4-West Branch Red Clay Creek	00391	17.6	0.1, one UNT	4.58 main stem; 3.56, 3 UNTs	Organic enrichment/low DO, siltation from AG
5-South Brook	00402	1.73			
5-Bucktoe Creek	00393	2.19		2.13 main stem; 2.21, 2 UNTs	Siltation & unknown toxicity from AG; Water/flow variability from Habitat modification

Streams are listed in order from upstream to downstream. A stream with the number 2 is a tributary to a number 1 stream, 3's are tributaries to 2's, etc. Delaware River=1

Total miles listed as impaired or attained include unnamed tributaries (UNTs) where indicated.

UNT= unnamed tributary, AG= agriculture, DO= dissolved oxygen

EV= Exceptional Value, HQ= High Quality, CWF= Cold Water Fishes, TSF= Trout Stocked Fishes